SQUIRREL CREEK ALLUVIAL VALLEY FLOOR DETERMINATION

I. Introduction

Squirrel Creek is a tributary to the Tongue River near Decker in southeastern Montana. For the purposes of this determination, the alluvial valley floor study area along Squirrel Creek extends from the creek's confluence with the Tongue River to a point about 4½ miles upstream. Two proposed coal strip mines are located within the study area. Neither company has as yet however applied to the Department of State Lands (DSL) for a permit. Instead, detailed studies of the presence and significance of an alluvial valley floor have been made by both companies so as to facilitate future planning.

The Consolidated Coal Company (Consol) and Peter Kiewit Sons', Inc. (PKS) have proposed to open separate coal strip mining operations adjacent to Squirrel Creek. The study area contains the two proposed mine permit areas and adjacent lands (see company alluvial isopach maps for permit areas).

At a minimum the reader should have a set from either company of the following maps to review various parts of this document:

Ranch Ownership:

CX Ranch Lands (PKS)

Lower Squirrel Creek Area Land Ownership Map (Consol)

Agricultural Fields:

Land Use History Map (PKS)

Lower Squirrel Creek Area Land Ownership Map (Consol)

Zero alluvial isopach line and proposed permit areas:

Revised Alluvial Isopach Map (PKS)

Squirrel Creek Alluvial Isopach Map (Consol)

What follows is documentation by DSL of the presence and extent of an allu-

vial valley floor within the Squirrel Creek study area. Also included is a discussion of the significance of such an alluvial valley floor to the farming operation in the area.

The proposed mining would occur on the present CX ranch. The CX ranch was formed in 1971 from 4 different ranches: 1) Mr. Oscar Cooke's "CX" ranch; 2) the Power's ranch; 3) Mr. Earl Simpson's "21" ranch; and 4) part of Mr. Claris Foss' ranch (see ranch ownership maps). The majority of the proposed mine areas was made up from the "21" ranch and the Powers ranch. Currently, all four ranches are operated as one by Mr. Charles Larson for Mr. Robert Connell who leases the property from Consol. Consol owns the surface and half the mineral rights and PKS the other half of the mineral rights within the proposed areas.

Both PKS and Consol coordinated closely with Departmental staff to work out details of the AVF studies for Squirrel Creek and the first formal study submittals from each company (prepared by one consultant) were essentially identical. This document (Hydrometrics, 1980a) was reviewed and the Department requested additional information in a letter of June 24, 1980. Various reports and responses which were developed separately by each company have been submitted in answer to the Department's June 24th letter. The most significant reports submitted were Hydrometrics (1980b, c) and Peter Kiewit Sons' (1980).

Departmental staff made field visits to Squirrel Creek on September 4-6 and October 6-8, 1980 and interviewed present and former ranchers on November 17-18, 1980. This document is based on these reports, interviews, and field visits.

II. Findings

DSL has determined that an alluvial valley floor exists within the study

area because:

1. Unconsolidated streamlaid deposits holding streams are present; and
2. there is sufficient water to support agricultural activities as evidenced by:
   A. the existence of flood irrigation in the Squirrel Creek valley and its historical use.
   B. the capability of the area to be flood irrigated, based on water yield, soils, water quality and topography; and
   C. subirrigation of the lands in question, derived from the groundwater system of the valley floor.

DSL's findings regarding each of these criteria are further explained below.

1. <u>Unconsolidated Streamlaid Deposits</u>

The extent of alluvial, or unconsolidated streamlaid deposits within the study area was identified by the companies on a surficial geology map based on mapping of surface soils and landforms and on an alluvial isopach map based on data from drill holes. These two maps indicate different extents of the alluvium in the Squirrel Creek valley. In particular, the alluvial isopach map, which is based on subsurface data, tends to document a wider and greater extent of alluvium then the surficial geology map. The distinction between alluvium and colluvium is relatively easy to make at the surface based on topography but is considerably more difficult to make at depth from drill hole logs (personal communication 11/18/80, Joe Gerlach, Hydrometrics hydrologist).

Important criteria used by Gerlach to distinguish the different subsurface

units within the Squirrel Creek study area are as follows:

<u>Alluvium</u>: gravel; gravel overlain by silt-clay deposits; massive silt-clay; stratigraphy less variable and units thicker than in colluvium.

<u>Colluvium</u>: thinly bedded deposits with varying textures; massive sands near sandstone cliffs (e.g. NW1/4, Section 29); thin gravels stratigraphically much higher than the typical alluvial gravels.

<u>Tributary gravels</u>: same as for alluvium; distinguishable from Squirrel Creek alluvium only by location.

<u>Ft. Union Formation</u>: color change from brown in unconsolidated deposits to grey in bedrock and the occurrence of white and black micas in the weathered bedrock usually give clearcut distinction between bedrock and overlying deposits.

Alluvial and colluvial gravels within the Squirrel Creek area could not be distinguished by the degree of rounding because some clearly alluvial gravels were angular. Angularity is usually assumed to be an indicator of colluvium.

DSL talked with the three geologists who had the recent responsibility of logging wells within the study area (Doug Parker, Hydrometrics, Jim Bowlby, PKS, and Joe Gerlach, Hydrometrics) and developing the alluvial isopach map (Gerlach). All three agreed that the following points are true:

A. Near the valley sides distinguishing colluvium from alluvium, particularly when fine-grained, is very difficult.

B. The location of the zero alluvial isopach line is not definitive as drawn by the companies and lateral shifting of the line would be plausible and just as defensible.

C. Drill holes near the valley sides in which only the gravel layer is

reported as alluvium may very likely have additional fine-grained alluvium not indicated by the company (see below).

D. Some drill holes near the valley sides with only fine-grained deposits may have alluvium which is indistinguishable from colluvium (see below).

In many cases, along the sides of the valley, only gravels were reported as alluvium and the silt-clay layer typically found overlying alluvial gravels was not distinguished. Gerlach (personal communication, 11/18/80) agrees with DSL's belief that in actuality, there is probably a greater thickness of alluvium in some drill logs than that reported. The separation of the alluvial silt-clay deposit (presumably overbank deposits) from fine-grained colluvium is not possible from drill logs. The following table lists wells for which DSL believes that the companies assumed that only gravel was alluvium.

WR-52E	5-79-80
SQ-16-75	CX-1-74
SQ-29-75	CX-6-74
S-43-79	CX-22-74
92-80	91-80

Other drill logs, for which the companies claim a certain thickness of colluvium, and no alluvium, have the potential to have indistinguishable alluvium. In some cases, the logs are too general and in other cases, DSL's interpretation is different from that of the companies. Drill holes with such attributes are as follows:

WR-52D	S-44-79	86-80

WCX-80	S-70-80	87-80
WCX-9E	S-78-80	89-80
WCX-12	S-81-80	90-80
WCX-28E	CX-1-77	93-80
SQ-16-75	CX-13-79	
S-41-79	CX-15-77	

Given the fact that: (1) DSL has interpreted the drill log data to indicate greater thicknesses of alluvium; and (2) that company geologists agree with DSL that the location of the zero isopach line for alluvium is somewhat arbitrary, DSL believes that unconsolidated streamlaid deposits underly all the area in the center of Squirrel Creek valley bounded on both sides by either:

1. the zero alluvial isopach line (see alluvial isopach maps submitted by both companies); or
2. one of the following irrigation ditches (see Figure 1):
    a. Cormack ditch
    b. Powers-Cormack ditch
    c. Powers Bros. ditch (also upper main ditch)
    d. lower main ditch

Thus, DSL believes that unconsolidated streamlaid deposits, are in fact, greater than that reported in the studies prepared by the two companies and the alluvial valley floor is, therefore, wider than that reported by the companies.

2. <u>Sufficient Water to Support Agricultural Activities</u>

A. <u>Existence and historic use of flood irrigation</u>

Flood irrigation is presently in use and has been in use since the late

1800's in the Squirrel Creek drainage. Historically, because the Powers had first water rights, most of the flood irrigation existed on the Powers' ranch, Mr. Simpson and Mr. Cooke had second and third water rights respectively. Because of the Power's excessive water use practices there was seldom water for Mr. Cooke or Mr. Simpson who both had potentially irrigable land.

The past and present irrigation practice is to divert water from Squirrel Creek, convey that water by open ditch on slopes less than the land slope to the field boundaries, then let the water flow downslope, irrigating the fields. This system requires cuts in the ditch banks and canvasses to stop the water flow in the ditch and cause it to spread downslope (Hydrometrics, 1980b, Appendix F).

Mr. Charles Larson, informed DSL that the ditches now in use are basically the same as when he started operating the ranch in 1971. The ditches that get the most use presently are the Powers-Cormack Ditch and the Powers Brothers Ditch or Upper Main Ditch (see Figure 1).

The amount of irrigation water depends on the amount of snowpack in the Wolf Mountains to the west of the operation according to the reports submitted to DSL by Consol and PKS.

B. Capability of the area to be flood irrigated

Based on a review of the water yield, water quality, soils, and topography, DSL has determined that all existing fields, within the AVF as defined by DSL have the capability to be irrigated. Each of the attributes is discussed below:

Topography

The fact that five flood irrigation ditches (see Figure 1) have been

constructed in the valley indicates that suitable topography is present for flood irrigation.

Non-irrigated areas above the existing ditches with suitable soil characteristics for flood irrigation are too high along the valley slopes for practical ditch construction for the following reasons:

1. Necessary ditch gradients would move the diversion points from Squirrel Creek upstream where less drainage basin area, and consequently less runoff, would contribute water for irrigation.

2. Ditch lengths would increase substantially, thereby contributing to excessive irrigation water conveyance loss and lower irrigation efficiency.

<u>Soils</u>

A preliminary soils map of the lower Squirrel Creek area (Camp, Dresser and McKee, 1980) was compared by the companies with those portions of lower Squirrel Creek valley presently or formerly flood irrigated. Particular soils were selected from this part of the valley on the basis of limiting irrigation characteristics. These limiting characteristics are: poor internal drainage, steep and erodible slopes, shallow depth to bedrock or water table, subirrigation and saline or sodic conditions. Of the 421 acres identified as being flood irrigated in the study area, 92 acres, or 22 percent, are underlain by soils possessing limiting characteristics. Soils limitations do not seem to have been strongly considered in the initial installation of the irrigation system, although isolated areas of decreased crop yields may exist. Therefore, the soils limitations of these 92 acres do not prevent these acres from being flood irrigated (Hydrometrics, 1980a).

Soils of limited irrigation capabilities exist in the lower Squirrel Creek valley. However, their distribution and influence upon additional and potential future irrigation in the area cannot be addressed more fully until detailed soils survey information is evaluated. Although identified properties of some soils theortically limit flood irrigability of these soils, current and historic flood irrigation practices in the valley indicates that these limiting properties are not significant.

Water Quality

Both companies have agreed, based on water quality data from the USGS gaging station, that the quality of spring runoff is suitable for irrigation. Because there is sufficient spring runoff water to irrigate all fields in the study area (see below), DSL has not looked at the quality of return flow water.

Water availability

The amount of water available for flood irrigation has been determined by three different methods chosen by the companies. Two methods, partially modified by DSL, produce comparable results and one is unsuitable.

Channel geometry method

PKS had E. R. Hedman work through his channel geometry method of determining mean annual runoff from active channel width. His calculations estimated 3200 acre-feet/yr of runoff near the USGS gaging station. He used a corection factor of 0.68, based on USGS gaging records, to determine 2166 acre-feet of runoff in the May - September period. Both companies (Hydrometrics, 1980a) and DSL (letter of 6/24/80) agree that the irrigation season typically is April 1 through the first week of June. The correction factor is then 0.85 and the

estimated irrigation season runoff is estimated at 2724 acre-feet using the channel geometry method.

Gaging station records

A USGS gaging station is located near the upstream end of the AVF study area. Records are available from September 1975 through 1979. DSL has eliminated the 1661 acre-feet resulting from flood flow on May 18-21, 1978 due to the very low frequency of this event. Consol has also adjusted the gaging record slightly to account for impoundment by an unbreached stock pond and for irrigation diversion just above the station (Hydrometrics, 1980b). The average runoff for 1976-79 during the irrigation season was 2306 acre-feet.

Average precipitation year

Both companies contend that the period of record for the USGS gaging station coincides with a period of above average rainfall and therefore the average recorded runoff is also high. A suggested solution is to look at an average precipitation year such as 1976. This choice of 1976 as a typical year should be juxtaposed with 1979 which also had below average precipitation but over twice the runoff as 1976. Both 1976 and 1979 were preceded by high precipitation years (about 100% and 50%, respectively, above normal). Obviously, precipitation records at Decker are not very suitable for predicting runoff in a drainage which extends about 20 miles upstream from Decker into the Wolf Mountains. Yearly snow pack information would probably be more useful. DSL therefore considers the average precipitation method unsuitable.

The average runoff for the irrigation season computed by the first two methods listed above is 2515 acre-feet. Using a 50% irrigation-ditch efficiency

and a 1.6 acre-feet/acre (Hydrometrics, 1980b) water requirement for alfalfa, there is sufficient water for irrigating 786 acres in the study area (a 50% irrigation ditch efficiency is considered a reasonable estimate for the ditches especially if proper water application management is assumed). Therefore, there is more than sufficient water to irrigate all fields in the study area which can or have been flood irrigated by existing ditches.

C. Evidence of Subirrigation in the Study Area

In resolving the question of subirrigation in the Squirrel Creek valley, DSL participated with Consol and Hydrometrics in digging 17 backhoe pits. DSL believes the data collected from those pits and our interpretation are valid since significant sites on both sides of the drainages were sampled. Site locations were jointly chosen by Consol, Hydrometrics and DSL. Root depths were measured and root concentrations were qualitatively observed. Where the water table was not intercepted, water level data was obtained from the closest well.

Subirrigation is defined, with respect to alluvial valley floors, as the supplying of water to plants from underneath or from a semi-saturated or saturated zone where water is available for use by vegetation. Subirrigation may be identified by:

a. Diurnal fluctuation of the water table, due to the differences in nighttime and daytime evapotranspiration rates.

b. Increasing soil moisture from a portion of the root zone down to the saturated zone, due to capillary action.

c. Mottling of the soils in the root zones.

d. Existence of an important part of the root zone within the capillary

fringe or water table of an alluvial aquifer.

e. An increase in streamflow or a rise in ground water levels shortly after the first killing frost on the valley floor.

Hydrometrics (1980b) reviewed continuous records from four wells and concluded that some diurnal fluctuation indicative of subirrigation did exist. Considering the small sample size (3 sites) and the intricacy of the process, DSL feels that more data would be required to increase the validity of the diurnal fluctuation measurement.

Soil moisture profile data collected by Hydrometrics (1980c) is inconsistent with that which is reasonable to expect. 0-bar water is water at saturation or standing water. All water tables shown in the Hydrometrics report are shown at .3 bar water. A conversation with Hydrometrics did not resolve this anomaly. Because of the anomaly, DSL has reservations concerning the validty of the soil moisture profile data presented.

Mottling occurs in 8 of 17 pits according to the Hydrometrics (1980c), however there are some inconsistencies with what is reported and what is expected. Mottling is a reflection of a fluctuating water table while gleying is a reflection of a static water table. Both are caused by reducing conditions that are indicative of water levels to the extent of the mottling or gleying. Pits 8, 11, and 16 had water levels reported at 8'4", 12'7" and 10'5" respectively, and no mottling reported. Six of the reported holes that had mottling had water tables deeper than 12'7" feet. DSL believes that mottling may have existed in pits 8, 11, and 16 and possibly others, but, the mottling or gleying was masked or difficult to observe and therefore was not accurately

reported. Therefore, although Hydrometrics reported that 47% of the pits exhibited mottling it is likely that an additional 18% or more of the pits had mottling that was not reported. How much of the mottling or gleying is due to subirrigation or flood irrigation is very difficult, if not impossible, to determine.

DSL considers the statement "an important part of the root zone within the capillary fringe or water table. . ." in ARM 26.4.301(72)(d) to mean that if 10% of the roots terminate below a capillary fringe that is within 6' of a water table that is within 19' of the surface, then there is a significant component of subirrigation. To arrive at these parameters DSL spoke to Dr. Doug Dollhopf and reviewed Dollhopf et. al. (1979).

Dollhopf et. al. (1979) cites Blad & Rosenburg (1974) who said that when roots were within 90 cm (3') of the water table, capillary rise was able to supply a maximum of .8 cm of water per day, which is about equivalent to the daily ET requirement for an alfalfa plant. When the water table was 180 cm (6') below the roots only .1 cm of water per day could be delivered by capillary rise. It should be noted that .1 cm is 12% of the ET requirement of a producing plant and, logically, a greater proportion of the maintenance quotient of that plant. The above figures are for a sandy loam soil and "should be considered a guideline since changing patterns of soil texture could increase or decrease this dimension by perhaps 50%" (Dollhopf et. al., 1979). DSL believes a 180 cm (6') capillary fringe can produce a significant amount of water to the maintenance quotient of a plant, and the existence of 10% of the roots within that distance would confirm that. In heavy textured soils capillary fringes much

greater than 6' are expected but soil water tensions may make water unavailable. Water tables within 19' were established as the lower boundary because: 1) Dollhopf considered this level to be the maximum depth at which some subirrigation was taking place at Snider's Field; 2) observation and data review indicate that a significant portion of the root zone lies within 6' of this level; and 3) because in speaking with Dr. Dollhopf, DSL felt that a 19' water level could produce water available to a plant that would be critical to that plants maintenance requirement. In 11 of 17 backhoe pits, 10% of the roots were within the capillary fringe (see following table).

Pit Number	Date	10% Of Roots Below	Depth to 6' Capillary Fringe
2	7 Oct 80	7'7"	7'6"
3	7 Oct 80	14'	13'
5	7 Oct 80	12'	6'6"
6	8 Oct 80	considered subirrigated by Hydrometrics	
7	8 Oct 80	10'11"	10'8"
8	8 Oct 80	water table within 10'4" of the surface - DSL expects alfalfa would be subirrigated	
9	8 Oct 80	8'3"	5'10"
11	8 Oct 80	water table within 12'7" of the surface - DSL expects alfalfa would be subirrigated	
12	8 Oct 80	9'	9'1"
15	8 Oct 80	9'4"	8'9"
16	8 Oct 80	6'10"	2'4" (greasewood)

Irrigation ceased within the proposed permit areas in early June, 1980. The fields within the proposed permit area produced 2 cuttings of alfalfa plus substantial regrowth. To explain this production DSL reviewed the SCS Montana Irrigation Guide. According to the SCS Guide, effective moisture from flood irrigation would last 17-19 days. Since the above mentioned production would

require more than 17-19 days of water enhancement, and realizing the relatively general nature of the SCS guide, DSL considered the SCS explanation invalid. At the other extreme, it seems unlikely that flood irrigation moisture was effective 4 months after it was applied. Therefore, because of the existance of 10% of the root mass within the capillary fringe of the majority of the backhoe pits, DSL believes there to be a significant subirrigation component at Squirrel Creek. Supporting this conclusion is DSL's belief that mottling exists in 65% or more of the pits reviewed.

Cursory review of streamflow hydrographs for Squirrel Creek at the USGS gaging station indicate that there is an increase in streamflow after the first killing frost. The lack of data for fall and winter months prevents analysis of seasonal water level fluctuations in wells.

3. Agricultural Production in Squirrel Creek Study Area

DSL believes that the most significant agricultural lands in the proposed permit area are the hayfields that border the drainage thru Section 24 and into the NW1/4 of Section 30. Consol has identified these as fields 3,6,7,8,9, and 11. Total acreage for these fields is 245 acres (as planimetered by DSL). Historically, these fields were part of the Powers ranch with the exception of 37 acres that belonged to the CX Ranch.

Until 1975, no accurate production figures were kept for the hayfields. Since 1975, however, Mr. Charles Larson, has kept hay production records for the consolidated ranch. Larson estimates production for the operation by estimating the number of stacks of hay produced (usually from two cuttings) and multiplying that times the estimated weight of one stack (see Figure 2 below).

The Squirrel Creek area's average precipitation of 11'8" (MDSL, 1980
it a suitable site for dryland alfalfa. Dryland alfalfa production for
Decker area averages approximately 1 ton/acre. Production for the curre
ranch in 1980 averaged 2.6 tons/acre. Data has not been kept for all fi
since 1975, however by extropolating from the past data, the 1978 produc
figure would be 4.7 tons/acre (Dr. Westesen in Hydrometrics, 1980b). Fi
shows the agricultural production figures for the proposed mine areas.

FIGURE 2

PKS	CONSOL FIELD #	ACRES	1980 Prod T	1980 T/acre	1976-80 Avg Prod	1976-80 T/acre
6	3	68	150	2.2	203	3.0
8	6	24	72	3.0	75	3.1
9	7	15	30	2.0	56	3.7
	8	43	172	4.0	NA	
	9	78	203	2.6	NA	
	11	17	19	1.1	NA	
		245	646			

Hay in 1980 sold for approximately $100/ton in the Squirrel Creek a
Ranchers without hay lands are more dependent on the hay market than th
hay lands and therefore may not be able to afford to overwinter livesto
prices in the Squirrel Creek area are double the 1978 prices (MT Dept.
Agriculture, 1980).

Today, there is little difference between current hayfield manageme
the way the Powers operated the ranch. DSL interviewed Esther Powers

grandaughter of the original homesteader, and her husband Nick Bumbaca. Mr. & Mrs. Bumbaca stated that the ranch normally wintered 100-200 head of cattle that required approximately 1-1.5 tons of hay per year and that the Powers' operation annually produced approximately 50% of its hay needs. The Bumbaca's estimated that without the irrigated fields, cattle production would have had to be reduced by 50%. The current operation is wintering 3-6 times more cattle than the past operation and producing at least 6-12 times more hay.

DSL believes that the most sensible and credible way to determine significance of the AVF lands within the study area is to look at both the past and current operations. One may obtain a better idea of the actual production by using the more accurate records which have been kept recently. By reviewing the past operation one realizes that regardless of production the above mentioned hayfields (Figure 2) were responsible for at least 50% of the Power's livestock production. These same fields are currently responsible for 100% of the hay requirements of Larson's 600 head operation.

A testimony to the importance of the Powers' hayland was the consistent attempts by Mr. Oscar Cooke, former owner of the CX ranch, to buy those lands (see ranch ownership maps). Unable to buy the Powers' hayfields and water rights, Mr. Cooke purchased 250 acres of hayland near Billings, using the CX for summer pasture.

Based on the above analysis, DSL feels that mining within one or both of the proposed permit areas would eliminate hay production which is very significant to the farming operation. Such hay production is important to the operation in terms of straight economic value and because of the independence it allows the

operation from the vagaries of the hay market. The high hay yields within the study area are directly attributable to flood irrigation and subirrigation within the drainage. Because of the importance of the hay to the operation, DSL feels that the proposed permit areas encompass areas of significant alluvial valley floor in Section 24, the NW1/4 of Section 30, and the SW1/4 SW1/4, Section 19.